

**ELECTROCHEMICAL RECOVERY OF COPPER,  
LEAD AND TIN FROM A NITRATE AND  
CHLORIDE LEACHING SOLUTION OF SCRAP  
PRINTED CIRCUIT BOARDS**

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The recovery of copper, lead and tin from scrap printed circuit boards (PCBs) has been achieved using a combination of leaching and electrodeposition. A simple aqueous nitric acid stripping solution, with the concentration range of 1-6 mol/dm<sup>3</sup>, has demonstrated the potential for selective extraction of copper and lead from the PCBs. Precipitation of tin as H<sub>2</sub>SnO<sub>3</sub> (metastannic acid) [1] occurred at acid concentration above 4 mol/dm<sup>3</sup>. Preliminary electrolysis from simulated and real leaching solutions has demonstrated the feasibility of electrodeposition of copper and lead at different concentrations of HNO<sub>3</sub> and different pH of NaNO<sub>3</sub> solutions, obtained after leachate neutralization.

The electrodeposition of copper and lead in nitrate environment has shown the influence of the acid strength on the efficiency of the process. Although the recovery of copper is feasible at low concentrations of HNO<sub>3</sub>, electrodeposition of lead has to be considered at higher pH to avoid dendritic metal formation and subsequent re-dissolution in the bulk. Alternatives that have been considered include the simultaneous electrodeposition of copper at the cathode and lead dioxide at the anode. Figure 2 shows plots of concentration versus time for both copper and lead using an undivided rotating cylinder electrode reactor (RCER) at three different current densities. Lead was deposited with high current efficiency (99%) as dioxide at a platinum coated titanium anode whilst copper was deposited simultaneously at the rotating cylinder cathode up to 73.5% current efficiency. After dissolution of the deposited copper from the cathode, the analysed solution contained 0.2% lead and 99.8% copper, confirming the absence of significant lead deposition. At the anode only lead was found.

The use of a flow-through porous electrode (carbon felt) has been shown to be very efficient for the electro-recovery of metal ions when the concentration of species in solution becomes of the order of 100 ppm. The large specific surface area along with the turbulence generated by the electrolyte flow through the porous electrode considerably improves the mass transport to the electrode surface leading to a greater rate of electrolysis in comparison with a two dimensional electrode. Mass transfer correlations are presented.

When hydrochloric acid is added to metastannic acid H<sub>2</sub>SnCl<sub>6</sub> is formed [2]. Preliminary current-potential linear sweep voltammetry confirmed tin deposition from a solution of 0.01 M H<sub>2</sub>SnCl<sub>6</sub> + 1.5 M HCl (Fig. 1). Galvanostatic electrolyses were carried out. The tin deposit obtained was adherent to the stainless steel cathode for lower current densities. At the higher current density, the morphology of the deposit appeared spongy due mainly to hydrogen evolution, which occurred when the tin concentration fell and current densities were greater than the limiting current density. Overall current

efficiencies for tin deposition were high and typically greater than 95%.

**ACKNOWLEDGMENTS**

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**REFERENCES**

1. Al-Suhybani AA, *British Corrosion*, **24**: 204-21 (1989)  
2. Scott K, Chen X, Atkinson JW, Todd M, Armstrong RD, *Resources, Conservation and Recycling*, **20**: 43-55 (1997)

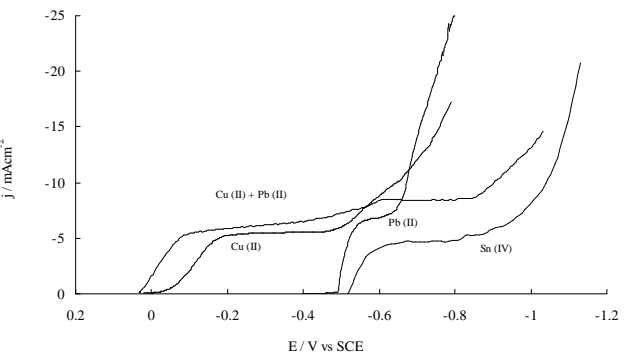


Figure 1. Linear sweep voltammetry for 0.01 M Cu(NO<sub>3</sub>)<sub>2</sub> + 0.5 M NaNO<sub>3</sub>, 0.01 M Pb(NO<sub>3</sub>)<sub>2</sub> + 0.5 M NaNO<sub>3</sub>, 0.01 M Cu(NO<sub>3</sub>)<sub>2</sub> + 0.01 M Pb(NO<sub>3</sub>)<sub>2</sub> + 0.5 M NaNO<sub>3</sub>, 0.01 M H<sub>2</sub>SnCl<sub>6</sub> + 1.5 M HCl. Scan rate 5mV/sec. pH 2

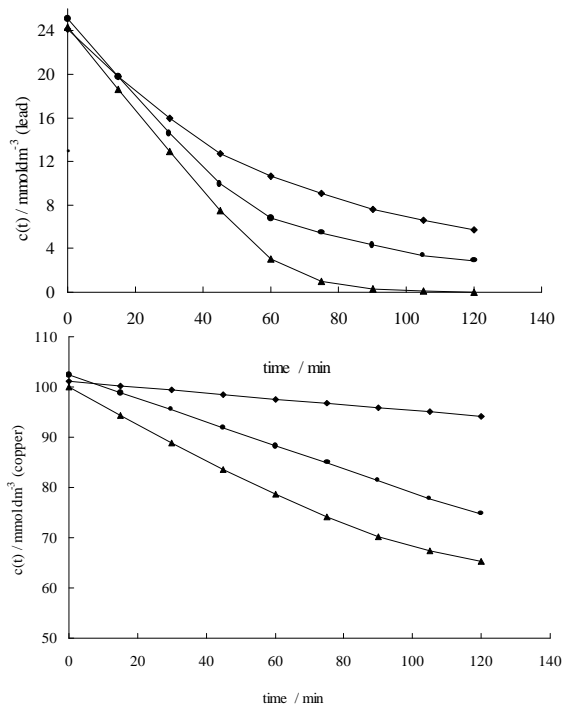


Figure 2. Concentration vs. time for constant current electrolysis (RCER) of 0.1 M Cu(NO<sub>3</sub>)<sub>2</sub> + 0.025 M Pb(NO<sub>3</sub>)<sub>2</sub> + 0.5 M HNO<sub>3</sub>. ♦ 10 mA/cm<sup>2</sup>, ● 30 mA/cm<sup>2</sup>, ▲ 50 mA/cm<sup>2</sup>.

